How the reverse supply chain impacts the firm's financial performance: A manufacturer's perspective

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Abstract

Purpose – Although manufacturers have traditionally viewed reverse supply chain (RSC) activities as a costly nuisance, more recent research has found that the RSC can contribute to the firm's financial performance. This paper identifies how the RSC can contribute to the firm's financial performance and examines the exogenous contingency factors decisive for the contribution's size. Because the exogenous factors are outside the control of the firm's operations and supply chain management, the factors influence the RSC's financial contribution irrespective of managerial policies and design decisions.

Design/Methodology/Approach – The paper applies a systematic literature review using the sequence of planning the review, searching and screening literature, extracting information from the selected literature, and synthesizing and analyzing findings. 112 papers were included.

Findings – The study has identified 15 distinct opportunities for RSC-contribution to the firm's financial performance. The study has identified 56 contingency factors. These are related to market segmentation, customer behavior, product design, and the firm's distributor network. The study includes an interrelationship network between factors and the RSC's contribution.

Practical implications – For managers, the paper shows how the RSC can increase the firm's financial performance and which contingency factors determine whether operating a RSC will be financially viable if implemented.

Originality/Value – While extant literature includes several reviews about RSC-related managerial policies and design decisions, this paper contains the very first collection of RSC-contribution opportunities available to manufacturers as well as the first review of exogenous contingency factors.

Key words Reverse supply chain, Reverse logistics, Closed-loop supply chain, Product recovery, Systematic literature review

Paper type Literature Review

Introduction

Over the past two decades, the industrial use of reverse supply chains (RSCs) as well as scholarly interest in the topic has increased substantially. Several reasons explain this development: "green" consumer segments are willing to pay premiums for sustainability in manufacturing, increasing raw material prices makes reuse attractive, RSCs can support competitive advantages, and in some industries regulatory compliance includes responsibility for product end-of-life (Stock *et al.*, 2002; Ginsberg and Bloom, 2004; Geyer *et al.*, 2007; Atasu *et al.*, 2008; Guide and Van Wassenhove, 2009). Following the prevalent RSC-concept by Guide and Van Wassenhove (2006), this study views the RSC as a set of five connected processes: Core product acquisition, reverse logistics, inspection and sorting, recovery, remarketing or internal reuse.

Huscroft *et al.* (2013) conclude that one of the greatest needs for academic RSC-research is examining ways to establish the RSC as a profit-center in the organization. The most prevalent type of extant RSC-research examines managerial policies and design decisions about e.g. network design and inventory lot-sizes. This study does not review literature researching managerial policies and design decisions. Instead, the study reviews RSC-related literature to identify how the RSC can contribute to the firm's financial performance, and to examine the exogenous contingency factors that are decisive for the size of the RSC's financial contribution. In the study, 'exogenous' refers to factors outside the control of the firm's operations and supply chain management. The exogenous contingency factors constitute the elements in the RSC's context that are relevant for the RSC's financial contribution irrespective of managerial design decisions and policies. For practitioners, these factors are relevant when evaluating whether to implement RSC-activities.

The purpose of this paper is to identify and critically review academic literature that contributes in answering the following three research questions:

RQ1: How can the RSC contribute to the financial performance of the firm?
RQ2: Which exogenous contingency factors influence the size of the RSC's contribution?
RQ3: How do the contingency factors relate to the RSC's contribution?

For RQ1, the study identifies a set of *functions* that the RSC can perform to contribute to the firm's financial performance. According to Larsen and Jacobsen (2014) a RSC-function is defined by three constituent elements: a process (e.g. repair or remanufacturing), an item (e.g. a complete end-product, a component, or a material), and a financially contributing purpose (e.g. increased revenue or reduced operating costs). Examples of RSC-functions are 1) refurbishment of end-products for resale in primary markets as a low-cost version of the virgin product, 2) refurbishment of components for reuse in refurbished products and for resale as spare-parts in the aftermarket, and 3) resale of core materials upstream in the supply chain to current suppliers of virgin materials. The totality of RSC-functions available to manufacturers constitutes the overall relationship between the RSC and the firm's financial performance.

According to Durach *et al.* (2017), understanding the conditions for when and how a relationship works, is key for literature reviews in the SCM-context. Therefore, the study examines the RSC's contextual factors that influence whether implementing any particular RSC-function will be financially viable. RQ2 concerns the identification of exogenous contingency factors, while RQ3 concerns developing an interrelationship network between (and among) contingency factors and the RSC's financial contribution.

The study provides managers with a broad array of potentially profitable RSC-functions and insights into the contingency factors influencing profitable operation. The study adds to the understanding of how the firms can utilize the RSC for the purpose of increasing the firm's financial performance, which is the crux of the emerging literature stream that applies a business perspective for analyzing RSC-issues (Guide and Van Wassenhove, 2006).

Domain limitation

All tiers in the supply chain (materials suppliers, manufacturers, distributors, wholesalers, and retailers) experience reverse flows. This study limits the domain to manufacturers following Geyer and Jackson (2004), Larsen and Jacobsen (2016), and Larsen *et al.* (2017): the focal firm conducts end-product assembly and fabrication of some components in-house, while remaining components and all materials are purchased; the firm's virgin products are durable and recoverable; the firm has a primary market for end-products and an aftermarket for spare-parts; recovered end-products and components have potential for remarketing in primary and secondary markets; and the firm has potential customers for core and recovered end-products, components, and materials.

The paper is organized as follows: First, the paper details the review methodology including screening criteria and procedure. Second, the paper presents findings including answers to the three RQs. Third, the paper discusses findings, provides suggestions for further research, and conclusions.

Methodology

The methodology follows the guidelines and sequence for a structured literature review prescribed by Denyer and Tranfield (2009) and the SCM-specific guidelines from Durach *et al.* (2017).

According to Durach *et al.* (2017) a structured literature review must choose a "theoretical lens on the phenomenon of interest". This study has chosen the RSC business perspective (Guide and Van Wassenhove, 2006) described in the paper's introduction. With this theoretical lens, the study follows a four step procedure depicted in Figure 1. First, the study locates papers; second, papers are screened for subject matter and quality; third, the study extracts data from the selected set of papers; and fourth, the study analyses findings to answer the study's three RQs.

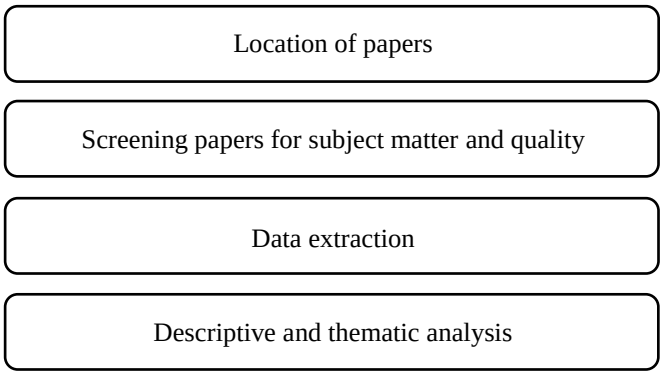

Figure 1. Research protocol

Location of papers

The review includes peer-reviewed English-language papers published since 1995 where the RSC's business perspective was born with Thierry *et al.*'s (1995) thought-piece paper describing the routes through a manufacturer's RSC. In 2009, Guide and Van Wassenhove stated that the field has grown from being a technically focused niche area in the mid-1990s to a fully recognized subfield of SCM.

The study combines the use of Web of Science and SCOPUS, which are broad-spectrum databases of high-ranking journals, and Emerald Insight, which focused specifically on the subjects that are most relevant to this study (operations management, logistics, and supply chain management). Table 1 details the search strings applied for each database.

Table 1 – Search strings

Database	Search string	Application of search string in database
Web of Science (Core Collection)	(TS=((reverse OR closed-loop) AND (supply OR demand OR value OR logistics OR procurement OR operation* OR production OR manufactur*) AND (chain* OR network* OR channel* OR system*) AND (cost OR profit* OR earning OR revenue OR turnover OR economic OR finance OR review))) AND LANGUAGE: (English) AND DOCUMENT TYPES: (Article)	- "TS=" refers to Web of Science's search in titles, abstracts and keywords - The search was limited to papers published between 1995 and 2017 - The search resulted in 2.840 hits. These were reduced to 1.209 when limiting to the relevant categories (e.g. Operations research management science, Engineering industrial, Management, Economics, and Business)
SCOPUS	(TITLE-ABS-KEY (reverse OR "closed loop" OR closed-loop) AND TITLE-ABS-KEY (supply OR demand OR	- TITLE-ABS-KEY refers to SCOPUS's search in titles, abstracts, and keywords

	value OR logistics OR procurement OR operation* OR production OR manufactur*) AND TITLE-ABS-KEY (chain* OR network* OR systems*) AND TITLE-ABS-KEY (cost OR profit* OR revenue OR turnover OR economic OR finance OR review)) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j"))	- The search was limited to papers published between 1995 and 2017 - The search resulted in 5.323 hits, which was reduced to 1.691 when limiting to relevant categories (e.g. Engineering; Environmental Science; Business, Management and Accounting; Decision Sciences; and Economics)
Emerald Insight	(reverse OR closed-loop) **in the title and** (supply OR demand OR value OR logistics OR procurement OR operation* OR production OR manufactur*) AND (chain* OR network* OR channel* OR system*) AND (cost OR profit* OR earning OR revenue OR turnover OR Economic OR finance OR review) **in other parts of the paper**	- The database allows for selecting in which parts of a paper individual search terms go. This study required relevant papers to have the words "reverse" or "closed-loop" in the title and all remaining terms anywhere in the paper - The search was limited to papers published between 1995 and 2017 - The search resulted in 195 papers

Screening papers for scope and quality

The screening process depicted in Figure 5 begins by removing duplicates and limiting results to relevant predefined categories. Second, the study screens for paper quality by including only papers within the first quartile of the Scimago Journal Ranking Index. Third, the study screens titles and abstracts for subject matter using the in- and exclusion criteria detailed in Table 2. Papers that pass the title and abstract screening subsequently undergo full review using the same in- and exclusion criteria. The subject matter screening was conducted and cross-validated by all four authors for the purpose of reconciling differences and ensuring coherence between RQs, screening criteria, and paper selection. Figure 2 shows the number of papers identified through the search strings and the number of papers excluded in each step of the screening procedure.

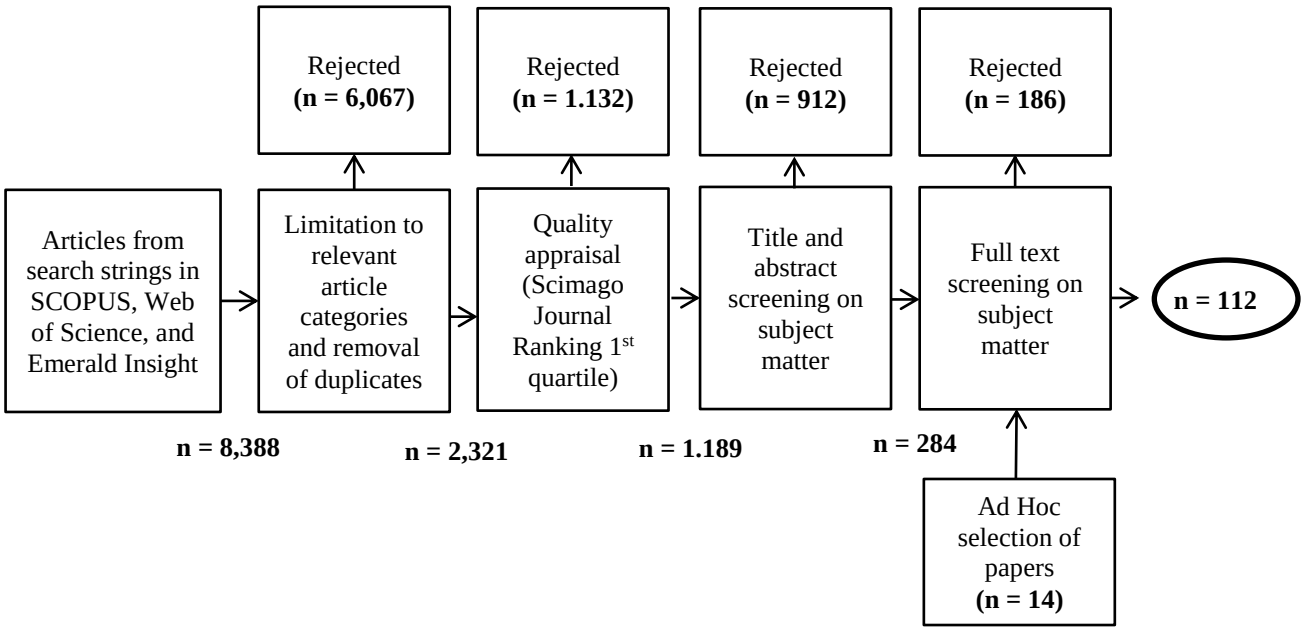

Figure 2. Screening process

The study has two inclusion criteria: 1) A selected paper must contribute to the understanding of how the RSC can contribute to the firm's financial performance. Papers that meet this criterion describe a *function* that the RSC performs for the firm that contributes to the firm's bottom-line

performance. 2) Because the size of the contribution from such RSC-functions depends on a number of contingency factors, the second criterion is that selected papers must contribute to the understanding of what these contingency factors are and how they influence the RSC's financial contribution.

A scoping study conducting prior to the paper selection process revealed that contingency factors are either endogenous with respect to the firm's operations or supply chain managers' control or exogenous. Examples of endogenous factors are management's ability to design a cost efficient core product collection network, use optimal inventory policies, and design the right contracts with downstream supply chain partners. These factors are within the immediate control of the firm's operations and supply chain management. Examples of exogenous factors are the fraction of the firm's market consisting of customers prone to returning used products, the recoverability of the firm products, and the degree of cannibalization of virgin product sales resulting from market introduction of recovered products. These factors are outside the control of the firm's operations and supply chain management. The study includes exogenous factors only and thereby focus on the factors that constitute the basis for a firm's RSC design and management.

The focus on exogenous contingency factors is novel in RSC-literature, which has researched and reviewed endogenous RSC subjects to a much larger extent (in particular analytical research concerning reverse logistics). For a comprehensive review of endogenous factors, we refer you to Govindan *et al.* (2015).

In addition to excluding papers researching endogenous contingency factors, the study is limited by its focus on the financial performance of manufacturers' use of the RSC. Following Durach et al. (2017), the study exclude papers based on their contribution to the RQs and not e.g. methodology choice. Table 2 lists the exclusion criteria.

Table 2 – Exclusion criteria

Exclusion criterion	Rationale
Firms outside the up- and downstream boundaries of the focal firm	The paper excludes firms outside the study's manufacturer focus (e.g. retailers, wholesalers, logistics providers, and materials manufacturers)
Manufacturers of non-durable goods	Manufacturers of non-durable goods (e.g. food and pharmaceuticals manufacturers) are excluded because these do not match the description of the study's focal firm
The RSC's "green" impact	The paper examines the relationship between the RSC and financial performance. Therefore, the RSC's impact on other sustainability measures is out-of-scope
Recycling processes	The focal firm does not conduct materials manufacturing in-house. Therefore, recycling processes are out-of-scope in the study
Waste management processes	The study excludes papers investigating waste management processes unless such processes are accompanied by reuse or recovery processes
Management capabilities and tasks	The study excludes papers that focus solely on management tasks and capabilities. How a firm designs its reverse logistical network, sets prices, inventory policies, etc. influences the RSC's profit contribution. However, the focus of the study is the exogenous factors that influence profits irrespective of management capabilities
Suppliers and third-party logistics providers	The study does not include issues related to suppliers (e.g. supplier selection) or the use of third-party logistics providers. The only exception is suppliers that function as buyers of core materials
Policy-maker oriented papers	The study excludes papers that have policy-makers as the explicit target group
Packaging materials	The study excludes papers that examine issues related to packaging materials
Recalls	The study excludes papers that examine issues related to recalls and other one-time take-back situations. Instead, the study focuses on continuously operating RSC-functions.

Data extraction

For each paper selected for full review, the study has filled an electronic data extraction sheet. The totality of data extraction sheets functions as the raw data for the analysis. The data extraction sheet has the following content categories: basic information (e.g. authors, journal, publication year, etc.), information for a descriptive analysis (e.g. applied method, studied industry, and geographical location), and the paper's contribution to the each of the study's RQs.

Descriptive and thematic analysis

While the descriptive analysis describes the selected papers' methodologies, years of publication, etc., the thematic analysis answers the study's RQs. For the thematic analysis, the selected papers represent a set of heterogeneous data that cannot be subjected to traditional aggregative synthesis (Rosseau *et al.*, 2008). Instead, the study applies an interpretive synthesis that looks for descriptive data and exemplars. From the data and exemplars the study extracts RQ-answers (Denyer *et al.*, 2008; Habib *et al*., 2015). For RQ1, the study identifies a set of discrete functions that emerge inductively from the data. For RQ2 and 3, the study identifies contingency factors described in literature and develops an interrelationship network.

The method for developing the interrelationship network is a sequence of 1) data coding, 2) qualitative interpretation, and 3) independent reviewer judgment. This interpretive method, which is the most prevalent method for developing causal networks in theory-building qualitative research (e.g. inductive case study research), uses the selected literature as the dataset from which the network is developed. Specifically, the study uses qualitative data coding (Miles et al., 2014) for the identification of factors and factor-relationships. Factor relationships appear both explicitly, vaguely, and implicitly stated in the dataset. The different degrees of explicity is one way the heterogeneity of the study's dataset materializes. Implicitly stated factor relationships resembles that of latent variables, which are not directly observable, but instead inferred from observed variables (e.g. Bentler and Weeks, 1980; Borsboom et al., 2003).

From the dataset, the study first develops a list with factors in one column and the factors' relationships to other factors in the adjacent column. The list is the basis for generating the causal factor interrelationship network through qualitative interpretation. The developed causal relationship network is subsequently revised and qualified through independent reviewer judgment. In a traditional qualitative study, causalities identified by the researcher are confirmed or revised by respondents (Miles et al., 2014), which in this study corresponds to validation by another author. The use of multiple reviewers improves rigorousness by reconciling divergent judgments (Rousseau et al., 2008).

Although the developed network represents current knowledge about contingency factors, the lack of explicit explanations weakens the strength of the network. The study therefore considers the network as basis for future research rather than a fully developed tool for practitioner decision making.

Descriptive analysis

The study has examined 112 papers that deal with a variety of RSC-issues. Among the 112 papers are ten literature reviews of which four have been published since 2015. Among the ten reviews, Govindan *et al.* (2015), Agrawal *et al.* (2015), and Govindan and Soleimani (2017) focus on the state-of-the-art of overall RSC-research, while Diallo *et al.*, 2017 focus on the narrower subject of quality and reliability as they relate to the RSC. The present study exhibits a series of traits that coincide with a number of previous literature reviews. As Souza (2013), the study reviews literature with an explicit manufacturer's perspective. As Atasu *et al.* (2008) and Guide and Van Wassenhove (2009) the study applies an explicit business perspective. As Cannella *et al.* (2016), the study examines factors that impact performance, and as Huscroft *et al.* (2013) and Hazen *et al.* (2012) the study reviews literature

for providing practitioners with decision making support. The combination of a manufacturer's focus, the use of a business perspective, examination of factors impacting performance, and focus on practitioner guidance, makes this study unique.

The study follows the guidelines of Denyer and Tranfield (2009), who advocate for a literature review method resembling reviews in medical journals. The purpose of medical literature reviews is offering guidance to practicing medical doctors on e.g. which medicine to prescribe for certain diseases. Likewise, the objective of the present review is offering guidance to practicing operations and supply chain managers about which RSC-functions to operate financially viable. This objective contributes to the understanding of how the RSC can constitute a profit center, which according to Huscroft *et al.* (2013) is one of two areas "in greatest need for additional scholarly attention".

Before answering the paper's research questions, the study conducts a descriptive analysis of the 112 papers. Table 3 presents the results.

Table 3 – Descriptive analysis

Descriptive category	**Subcategory**	**Number of papers**
Research methodology	Mathematical modelling	56
	Case and field research	26
	Survey research	11
	Literature review	10
	Experimental design	7
	Conceptual development	2
Year of publication	Before 2001	4
	2001-2005	12
	2006-2010	26
	2011-2015	44
	After 2015	26
Geographical location	Europe	29
	North America	39
	Asia	40
	Other	4
Industry sector	Electric and electronic industries	25
	Automotive	4
	White goods and copy-machines	3
	Other industries and multi-industry	5
	Not industry specific	75
RSC-objective	Increased revenue	46
	Cost reduction	24
	Both	29
	Not explicit	13
Core product type	End-of-life	22
	End-of-use	8
	Repair return (product is in use)	2
	Commercial return	2
	Multi-type returns	17
	Not explicit	61

Table 3 shows that half of the selected papers apply mathematical modelling as research method. Of the remaining other half, most papers conduct either case and field research or survey research. The publication frequency increases dramatically over the total period. While 16 papers were published between 1995 and 2005, the five year span between 2011 and 2015 produced 44 papers. 2016 and onwards has produced 26 papers so far indicating a massive research-increase. The geographical location is spread rather evenly between North America and Asia, with Europe lacking a bit behind. Among the 40 Asian papers, China, India, and Iran are well-represented. Only 38 of 112 papers studied a specific industry. The electric and electronic products industry is with 25 papers the most investigated industry. When examining the RSC-functions studied in the selected papers, 46 papers examine functions with the objective of increasing the firm's revenue, 24 papers study RSC-functions with a cost reduction objective, and 29 papers study RSC-functions with both objectives. Around half of the selected papers study a specific type of core product (e.g. end-of-life or end-of-use products).

43 papers include an explicit definition of the RSC or a related term, e.g. remanufacturing, reverse logistics, and closed-loop supply chain (CLSC). Table 4 lists the definitions, original source, and how often a definition appears within the selected papers.

Table 4 – RSC-definitions

Definition of RSC or related term	Original source	Appearances
"The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal"	Rogers and Tibben-Lembke (1999)	11
"CLSC management is the design, control and operation of a system to maximize value creation over the entire life cycle of a product with dynamic recovery of value from different types and volumes of returns over time."	Guide and van Wassenhove (2006)	7
The reverse supply chain consists of "Product acquisition… Reverse logistics… Inspection and Disposition… Reconditioning… Distribution and Sales"	Guide and Van Wassenhove (2002)	5
"Remanufacturing is a production strategy whose goal is to recover the residual value of used products by reusing components that are still functioning well"	Debo *et al.* (2005)	4
"from a business logistics perspective, the term refers to the role of logistics in product returns, source reduction, recycling, materials substitution, reuse of materials, waste disposal, and refurbishing, repair, and remanufacturing"	Stock (1998) (from Hazen *et al.*, 2012)	3
Other definitions		13

Eleven papers apply the definition of reverse logistics by Rogers and Tibben-Lembke (1999), which defines reverse logistics as a set of management processes ("…planning, implementing, and controlling…". The definition details which particular processes that reverse logistics manages and for what purpose ("…recapturing value…"). The CLSC-definition by Guide and Van Wassenhove (2006) also describes management processes ("…design, control and operation…"). While the CLSC-definition is unclear about which specific processes constitute the CLSC, the definition is quite clear about the purpose of the processes ("…maximize value over the entire life cycle of a product…"). As the present study, five papers apply the RSC-definition by Guide and Van Wassenhove (2002). This definition defines the RSC after its primary activities. Debo *et al.* (2005) focuses on the objective of the remanufacturing as recovering residual value, while Stock (1998)

views the RSC from a business perspective. The set of definitions focus on the business-related objectives of the RSC rather than the nuts-and-bolts technical issues of operating a RSC.

Thematic analysis

The structure of this section follows the paper's three RQs. RQ1 concerns the identification of RSC-functions that contribute to the firm's financial performance. RQ2 concerns exogenous contingency factors decisive for the size of the RSC's financial contribution. RQ3 concerns the relationships between contingency factors and the RSC's financial contribution.

Identification of RSC-functions that contribute to the firm's financial performance

The paper is built on the assumption that a firm's financial performance – simply stated – is the result of subtracting costs from revenue. Consequently, a RSC-function can contribute to the firm's financial performance by either increasing revenue or reducing costs. The study therefore disaggregates RQ1 into two subquestions: 1) which RSC-functions increase the firm's revenue?, and 2) which RSC-functions reduce the firm's operating costs?

How can the RSC increase the firm's revenue? Figure 3 shows ten RSC-functions that increase the firm's revenue. The ten functions increase revenue through resale of materials, components and end-products in either core or recovered condition, and through added service sales. The RSC-function "Recovery and resale of end-products" is by far the most researched function, while resale of core items is nearly unexplored. In addition to the direct revenue the firm receives for selling core or recovered items or service, the RSC can increase the firm's virgin product revenue. The two functions "Repair of end-products as a service" and "Take-back of end-products to enable a liberal return policy" increase the value of the total product offering, which results in higher virgin product revenue (Mukhopadhyay and Setoputro, 2004; Amini *et al.*, 2005; Skinner *et al.*, 2008; and Li *et al.*, 2014).

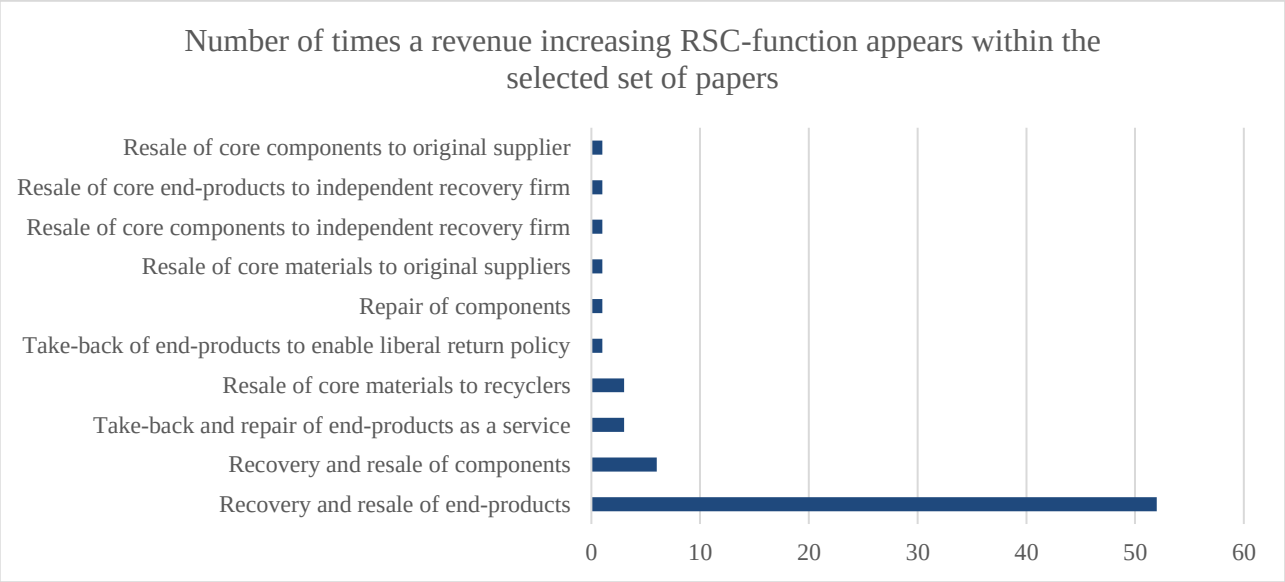

Figure 3. Revenue increasing RSC-functions identified in literature

In addition to the revenue sources described above, the RSC-functions give the firm a number of added benefits of which some increase revenue. Table 5 lists these benefits that increase revenue.

Table 5 - Added benefit resulting in increased revenue

No.	RSC-function	Added benefit
1	Recovery and resale of end-products	If the firm has a large share of customers that are unwilling to purchase a recovered product, then the firm can achieve higher revenue from virgin product sales, because the presence of a recovered product in the market enables firms to increase their prices on their virgin products (Abbey *et al.*, 2015)
2	Recovery and resale of end-products	Reselling recovered products can deter a low-cost competitor from entering the market, because recovered products represent a direct competitor (Zhou *et al.*, 2013)
3	Recovery and reuse of components	The function reduces the firm's purchasing volumes of virgin components made of virgin materials. If these virgin materials are expensive, the firm's ability to compete on low costs increases (Bell *et al.*, 2013).
4	Take-back of core product from customers	If products are physically taken back in the firm's retail outlets, then the firm's revenue increases because of customers' mere presence in the retail outlets (De Giovanni *et al.*, 2016).
5	All RSC-functions	For firms in markets with high green customer fractions implementing recovery operations augments the firm's brand image, which increases the firm's virgin product revenue (Larsen and Jacobsen, 2016).
6	Recovery of end-products	Offering a RSC-enabled leasing option can attract new customers (Mont *et al.*, 2006).
7	Take-back of core products	The function prevents independent recovery firms from reselling the firm's products and thus preventing virgin product sales cannibalization (Wu and Wu, 2016).
8	Take-back of end-products	A smooth return process enhances the relationship the firm has with its distributors, resellers, and retailers. These partners' behavior impacts future virgin product sales (Vlachos, 2016).

Generally, the results of this review suggest revenue from two overall categories: 1) revenue from sales of items processed in the firm's RSC and 2) revenue from added sales of virgin products. Core products can be sold in either core or recovered condition to a wide array of potential buyer groups, and the RSC enables added sales of virgin products through a wide array of enablers.

How can the RSC reduce the firm's costs? Figure 4 shows five cost-reducing RSC-functions. The RSC reduces the firm's costs by reusing end-products or components, which may or may not need recovery. Common for these four functions is that they all reduce the firm's costs by replacing virgin items with recovered items or directly reusable items. Recovered end-products can replace virgin end-products and recovered (or directly reusable) components can replace virgin components (Kroon and Vrijens, 1995; Fleischmann *et al.*, 2003; Georgiadis and Athanasiou, 2013; Huynh *et al.*, 2016). The question is under which circumstances a customer will accept a recovered end-product or a recovered component. Ferrer and Ketzenberg (2004) and Ghayebloo *et al.* (2015) describe how recovered components can replace virgin components in the firm's service operations, while Larsen and Jacobsen (2016) report on a case study where a firm uses recovered products to replace defective products that are still under warranty. In addition to replacing virgin items, the RSC can reduce the firm's costs by learning the reasons for why customers return the firm's products. Solving return-inducing problems reduces the costs of handling returns.

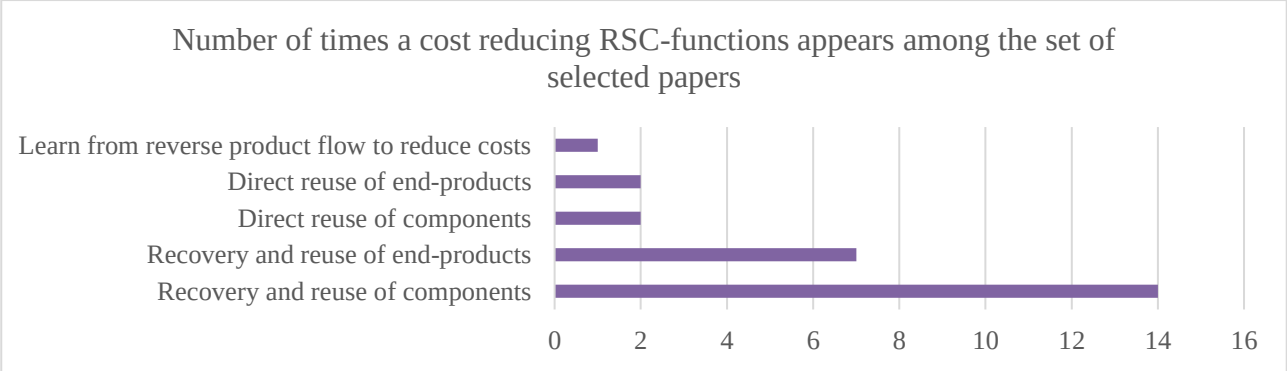

Figure 4. Cost reducing RSC-functions identified in literature

The study has identified two added benefits from operating RSC-functions that replace virgin items with recovered items. These two are described in Table 6.

Table 6 – Added benefits resulting in lower costs

No.	RSC-function	Added benefit
1	Recovery of end-products or components	These functions reduce the firm's scrapping costs by recovering products and components instead of scrapping them (Webster and Mitra, 2007)
2	Recovery and reuse of components	Reducing the costs of purchasing the often high-priced spare parts for products that are out-of-production, but still in the service period (i.e. in the installed base). These parts are often purchased as one very large "final" order, which takes place when the parent product goes out of production, and (if needed) small order replenishments. A function that continuously recovers components for reuse as spare parts saves the firm the added costs of the parts. In addition, the firm avoids the costs of holding the initial large order as spare parts inventory (Inderfurth and Kleber, 2013).

Generally, the overall way the RSC can reduce the firm's costs is by replacing virgin items with recovered items. Replacing virgin end-products with recovered end-products is the highest value RSC-function because end-products entail the maximum amount of value. Such a RSC-function replaces all costs from the finished goods warehouse and all the way upstream, including assembly costs, component manufacturing costs, materials purchasing costs, and all logistical and material handling costs. Salvaging reusable components replaces all costs from the firm's component manufacturing facility and upstream in the supply chain. Reusing an in-house produced component instead of manufacturing a virgin component saves the firm the costs of purchasing materials in addition to the costs of manufacturing the component.

The contingency factors decisive for the size of the RSC's contribution

While the two previous sections showed how the RSC can contribute to the firm's financial performance, this section presents the contingency factors decisive for the RSC's contribution size. Table 7a-b show the contingency factors, the number of times each factor is examined within the selected papers, and the specific papers addressing the factor.

Table 7a

Factor	Number of papers*	Papers addressing the factor
Core product quality	10	Aras *et al.* (2004), Bhattachary and Kaur (2015), Chen *et al.* (2015), Dehghanbaghi *et al.* (2016), Krikke *et al.* (2013), Li (2013), Mitra (2007), Keyvanshokooh *et al.* (2013), Zikopoulos (2017), Moshtagh and Taleizadeh (2017)
Core product recoverability	8	Abdulrahman *et al.* (2015), Debo *et al.* (2006), Dehghanbaghi *et al.* (2016), Ghayebloo *et al.* (2015), Huynh *et al.* (2016), Pigosso *et al.* (2010), Thierry *et al.* (1995), Zikopuolos and Tagars (2007)
Amount of incentive necessary to reaquire core products	7	Aras and Aksen (2008), Das and Dutta (2013), Das and Dutta (2015), De Giovanni *et al.* (2016), Dutta *et al.* (2016), Heydari *et al.* (2017), Das and Dutta (2016)
Customers' valuation of RSC-enabled services (e.g. repair)	6	Larsen and Jacobsen (2016), Li *et al.* (2014), Mukhopadhyay and Setoputro (2004), Skinner *et al.* (2008)
Products marginal loss of value over time	4	Blackburn *et al.* (2004), Guide *et al.* (2005), Hazen *et al.* (2012), Morana and Seuring (2007)
Customers' willingness to pay for recovered products	4	Dowlatshahi (2010), Wang *et al.* (2013), Xiong *et al.* (2016), Guide and Li (2010)
The time between virgin product purchase and return	4	Clottey and Benton (2014), Morana and Seuring (2007), Wang *et al.* (2017), Wilson *et al.* (2017)
The degree of cannibalization of virgin product sales	4	Abbey *et al.* (2015), Abdulrahman *et al.* (2015), Pince *et al.* (2016), Guide and Li (2010)
Uncertainty in the return volume	4	Mukhopadhyay and Setoputro (2014), Amin *et al.* (2013), Mahmoudzadeh *et al.* (2013), Clottey *et al.* (2012)
Core product availability	3	Abdulrahman *et al.* (2015), Debo *et al.* (2006), Larsen and Jacobsen (2016)
Amount of avoided scrapping costs resulting from reuse	3	Dowlatshahi (2010), Loomba and Nakashima (2012), Webster & Mitra (2007)
Importance of sustainability to customers	3	Abdulrahman *et al.* (2015), Zhang et al (2016), Ülkü and Hsuan (2017)
Consumers' perception of recovered products' quality	3	Hazen *et al.* (2011), Abbey *et al.* (2017), Atasu *et al.* (2010)
Virgin product or component costs that reuse replaces	3	Spengler and Schröter (2003), Tan *et al.* (2003), Pince *et al.* (2016)
Uncertainty of the market size for recovered products	2	Chen *et al.* (2015), Jindal and Sangwan (2014)
The volatility of return volume	2	Aras *et al.* (2004), Canella *et al.* (2016)
External preassure (societal, market, institutional)	2	Khor *et al.* (2016), Hung Lau and Wang (2009)
The costs of operating the RSC	2	Dowlatshahi (2010), Jindal and Sangwan (2014)
The number of recovery cycles per product	2	El Saadany *et al.* (2013), Gobbi (2011)
The costs of acquiring core products	2	Jindal and Sangwan (2014), Wu and Wu (2016)
Size of initial investment in RSC facilities and processes	2	Dowlatshahi (2000), Abdulrahman *et al.* (2015)
Effects of RSC-enabled services on virgin prod. revenue	2	Huang *et al.* (2015), Dowlatshahi (2010)
Uncertainty of core product quality	2	Robotis et al (2012), Zikopoulos (2017)

* Number of papers that address the factors

Table 7b

Factor	Number of papers	References
Share of recoverable parts in core products	2	Bakal and Akcali (2006), Langella (2007)
Share of functionality-oriented customers in the market	2	Atasu *et al.* (2010), Wu and Zhou (2015)
Product portfolio diversity	2	Amini *et al.* (2005), Huang and Su (2013)
Physical complexity of product (e.g. diversity of parts)	2	Chan *et al.* (2012), Subramanian *et al.* (2013)
Effect of recovered product sales on competitor entrance	2	Zhou *et al.* (2013), Atasu *et al.* (2008)
Customers' aversions towards recovered products	2	Abbey *et al.* (2015), Neto *et al.* (2016)
Resale's effect on virgin products' prices (and revenue)	1	Abbey *et al.* (2015), Larsen and Jacobsen (2016)
The value gap between core and recovered product	1	Larsen and Jacobsen (2016)
Size of return volume	1	Chen *et al.* (2015)
Risk of brand value erosion from independent firm resale	1	Larsen and Jacobsen (2016)
Proximity between customer and return center	1	Aras and Aksen (2008)
Product modularity	1	Krikke *et al.* (2004)
Product life-cycle longevity	1	Larsen and Jacobsen (2016)
Market price of scarce materials that reuse replaces	1	Bell *et al.* (2013)
Knowledge of installed base locations	1	Morana and Seuring (2007)
The effect of goverment subsidies for recovery	1	Mitra and Webster (2007)
Ease of core product inspectability	1	Van Wassenhove and Zikopoulos (2010)
The diversity in the firm's retailer network	1	Chan *et al.* (2012)
Degree of product customization	1	Larsen and Jacobsen (2016)
Customers' willingness to return core products	1	Aras and Aksen (2008)
Customers' risk in using recovered items	1	Chan *et al.* (2012)
Costumers' ambiguity tolerance	1	Hazen *et al.* (2012)
Core product return rate	1	Huynh *et al.* (2016)
Core product dimensions	1	Larsen and Jacobsen (2016)
Component recoverability	1	Krikke *et al.* (2003)
Ability to innovate using information from RSC	1	Vlachos (2016)
Share of market willing to purchase a recovered product	1	Lebreton and Tuma (2006)
Reputation of the seller of the recovered product	1	Subramaninan and Subramanyam (2012)
Consumer product knowledge	1	Wang and Hazen (2016)
Reliability of recovered product	1	Diallo *et al.* (2017)

Generally, the contingency factors concern the firm's markets, customers, and products. The contingency factors reflect the dual function of the firm's markets as both as supplier and customer. On the supply-side, the RSC's contribution is impacted by customers' willingness to return core products, while the demand side is impacted by customer willingness to purchase and pay for recovered products. How the market is divided into distinct groups impacts the RSC's financial contribution. For example, the share of functionality-oriented customers willing to purchase a

recovered product and the share of customers prone to purchasing a recovered product at the expense of a virgin product. Product design impacts components and end-product recoverability, the fraction of reusable components, and scrapping costs. Several contingency factors concern operational uncertainties. While forward operations can make detailed agreements with suppliers concerning reorder points, order quantities, and delivery times, managing the return flow is more uncertain, e.g. core product volume and quality, and demand for recovered products.

The interrelationships between contingency factors and the RSC's contribution

This section places the identified contingency factors in a network to illustrate the interrelationships among factors. The content and structure of the interrelationship network depends heavily on the specific RSC-function. For example, the factor "Customers' willingness to pay for recovered products" has no relevance for an RSC-function that reuses components internally without ever selling these. Figure 3 shows that the by far most researched function is "Recovery and resale of end-products". This study develops an interrelationship network for this function to ensure the largest possible integration of contingency factors identified within the selected papers. Figure 5 illustrates this RSC-function. The function takes back core end-products for recovery and remarketing.

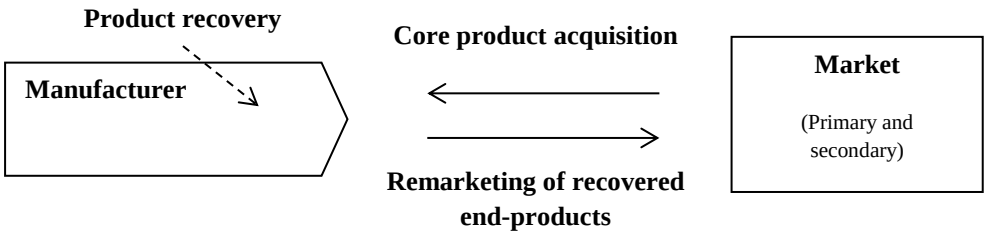

Figure 5. The RSC-functions "Recovery and resale of end-products"

The overall principle for how this RSC-function contributes to the firm's financial performance is captured in the following expression:

$$C = RS - (CP + CA) + AB - IC$$

C: RSC-function's contribution to the firm's financial performance
RS: Revenue from sales of recovered products
CP: Costs of RSC-processes
CA: Costs of acquiring core products
AB: Value of added benefits resulting from operating the RSC-function
IC: Indirect costs of operating the RSC-function

The first part of the expression, RS – (CP + CA), concerns the revenue achieved from resale of recovered products minus the costs of acquiring core products and processing them. The latter part of the expression, AB – IC, concerns the value of the RSC-function's added benefits minus the indirect costs of operating the function. In total, the expression contains five variables, each of which are influenced by the contingency factors in Table 7a-b. The following subsections show five separate interrelationship networks following the five-variable structure of the expression above.

Figure 6 shows the network of factors influencing RS. The network shows that RS depends on the share of the market willing to purchase a recovered product and the price customers are willing to pay. Willingness to pay is influenced by, among others, consumer perception of product quality, the

risk when using a recovered product, the time between recovery and original production, and the fractions of the firm's market that are green/sustainability-oriented and functionality-oriented.

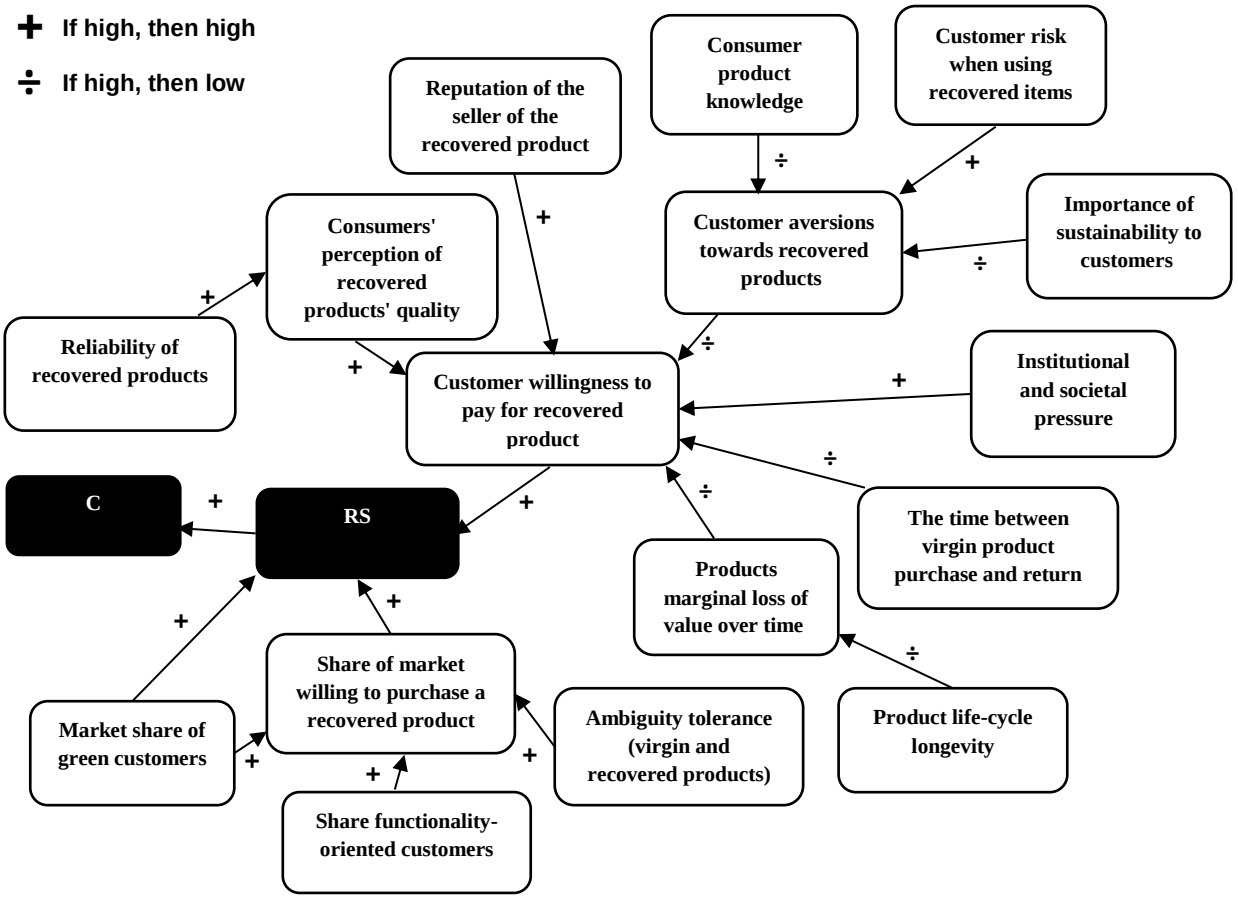

Figure 6. Factor network map for RS – Revenue from resale

Figure 7 shows the network of factors influencing CP. The network shows that CP largely depends on the return volume, which if large allows for economies of scale, and characteristics of the firm's product (e.g. product complexity and dimensions, product portfolio diversity, and the ease of inspecting core products). Finally, CP is influenced by uncertainties in the demand for recovered products, core product quality and core product volume.

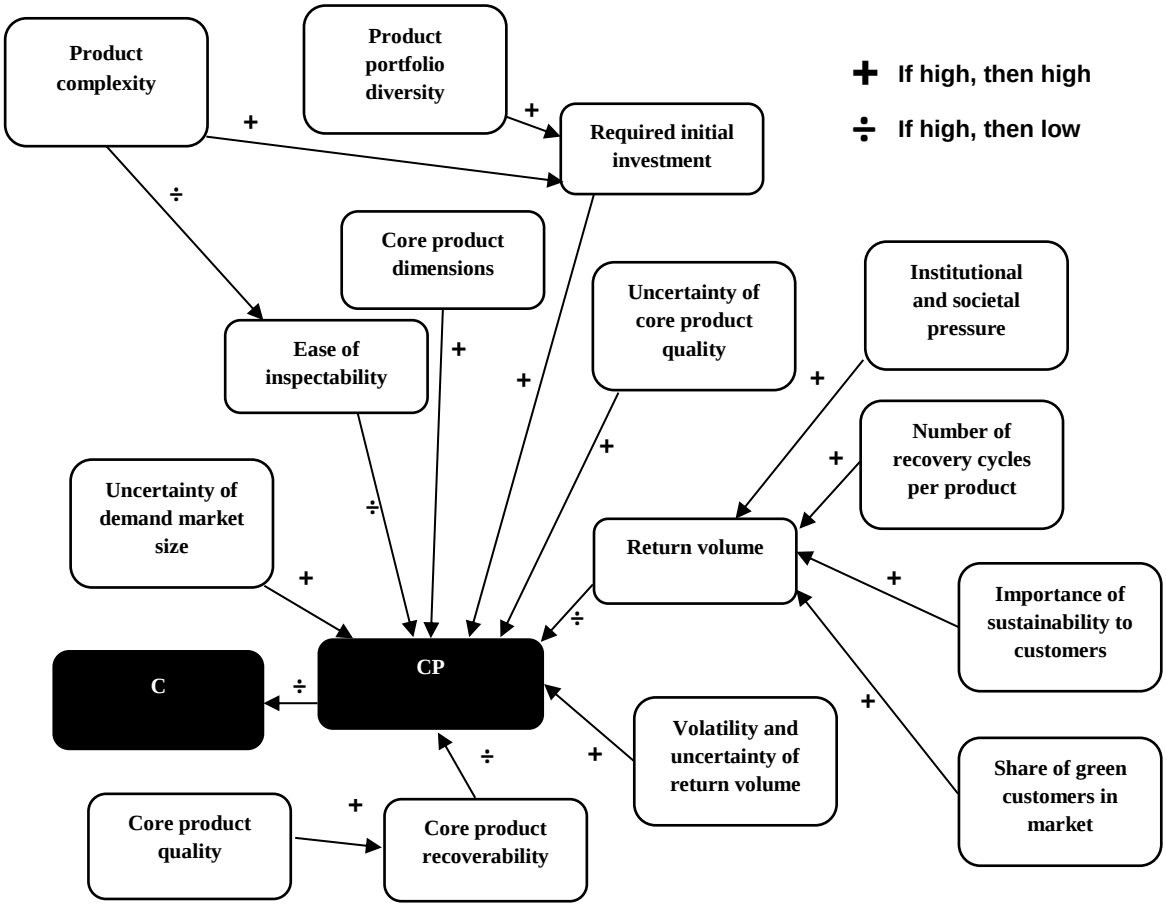

Figure 7. Factor network map for the variable RSC process costs (PC)

Figure 8 shows the network of factors influencing CA. The network shows that CA depends on the needed effort for accessing core products. Often examined factors are customers' willingness to return products and the necessary incentive for reacquiring core product ownership. If willingness is low and the necessary incentive high, then CA is high. The internal effort of increasing the core product flow also depends on the inherent diversity in firm's downstream retailer network, the firms' own knowledge of their installed base location, the recoverable fraction of core products and whether core products are customized to a degree that makes recovered products unsellable.

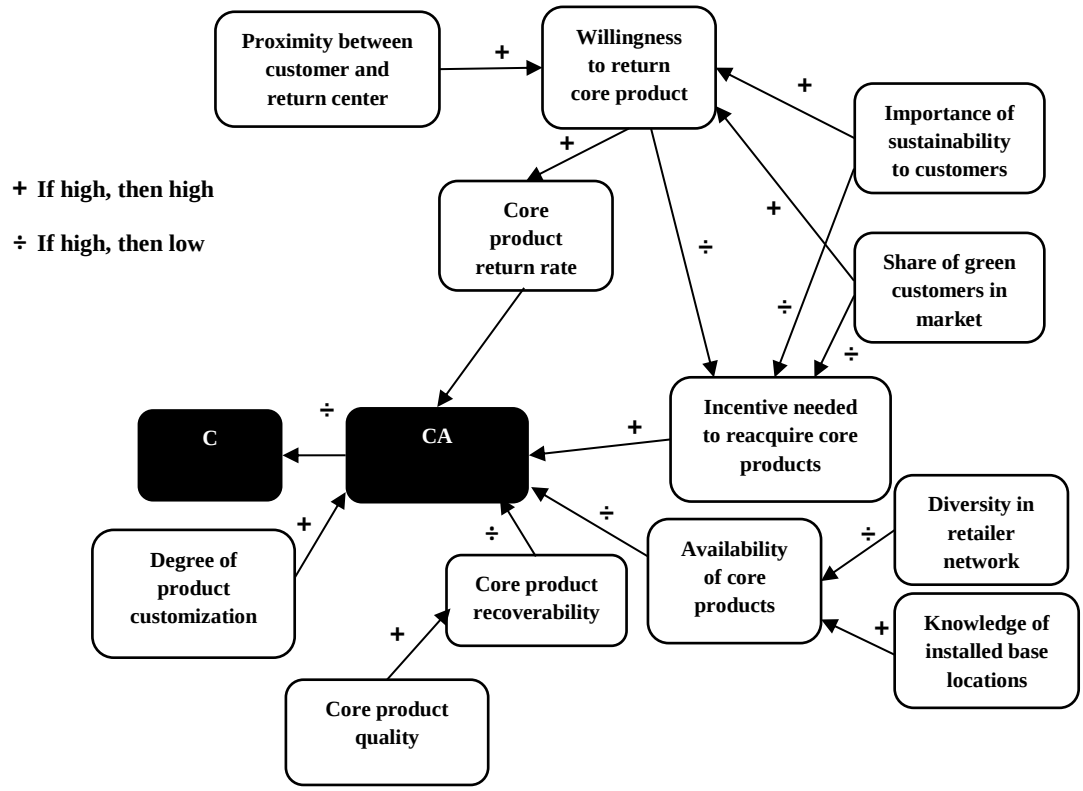

Figure 8. Factor network map for the acquisition cost (AC)

Figure 9 shows the network of factors influencing AB. Literature contains six added benefits of the RSC-function "Recovery and resale of end-products". The function acts as a deterrent to competitor entrance because resale in effect functions as a low-price supplier in the market. The function enables increasing virgin product prices if the market contains enough customers that are unwilling to purchase a recovered product regardless of the price difference. Furthermore, added benefits include potential government subsidies for sustainability, a greener brand image, and reductions in brand image risks resulting from resale of products recovered (with lower quality) by independent recovery firms (IRFs). Moreover, recovery lowers the firm's scrapping costs relevant for manufacturers responsible for managing products' end-of-life. Lastly, the RSC reveals why customers return the firm's products, which is relevant information for innovation and problem-solving, which leads to higher quality and subsequently higher customer satisfaction and retention.

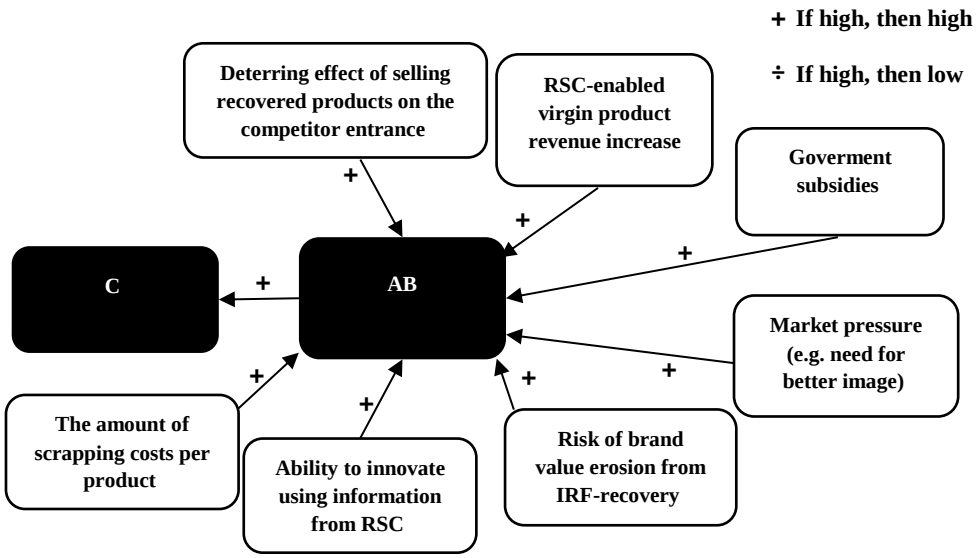

Figure 9. Factor network map for the variable RSC process costs (PC)

The final variable in the expression for the RSC's contribution to the firm's financial performance is the indirect cost of operating the RSC-function, IC. The only indirect cost mentioned in literature is the cannibalization effect resale of recovered products has on the firm's virgin product sales.

Discussion

The descriptive analysis shows that the number of published papers has increased massively since the 1990s. This development reflects both the increasing focus on sustainability and the emergence of the business perspective within RSC-literature. Around 90% of the selected papers have been published after Guide and Van Wassenhove's 2006 introduction of the business perspective in RSC-research. The study found 18 different RSC-definitions. The most widely used terms view the RSC through a business lens. However, the results show that even the most applied definition appears in only 8% of the selected papers, suggesting that the field is has not yet consolidated around one particular understanding of the RSC.

The study has identified 15 RSC-functions, which each can contribute to the firm's financial performance. One RSC can, however, consist of several RSC-functions. Guide and Van Wassenhove (2006) call for research about RSCs with "a cascading nature", which means a RSC with both high- and low-value functions. The concept of the RSC-function operationalizes a cascading RSC enabling research with a more tangible grasp on how the activities within a RSC contribute to the firm's financial performance.

In addition to the 15 functions the study identified ten added benefits from operating RSC-functions. As the 15 functions, these added benefits contribute to the firm's financial performance as well, albeit more indirectly. Of the ten added benefits, eight increase the firm's virgin product revenue, for example by deterring competitor entrance, increasing revenue from impulse purchasing, and attracting previously un-addressable customers with lower priced recovered products. The final two added benefits reduce the firm's costs by avoiding unnecessary scrapping costs and reducing the need for carrying large volumes of "last buy"-inventory. The set of added benefits indicates the heterogeneity of the impact the RSC has on the firm's financial performance.

The results suggest that contingency factors are related to primary market structure, customer behavior, product design, and the manufacturer's downstream distributor network. A market well suited for RSC-operation has large fractions of green and functionality-oriented customers. Green

customers value a manufacturer's green image and the possibility for returning a product for recovery. These characteristics indicate a high willingness to purchase and pay for recovered products. Functionality-oriented customers have low aversions against purchasing recovered products, have knowledge of the product, and are willing to pay high prices. Customers exhibiting behavior that is well-suited for RSC-operation are willing to return products despite return location distances and without financial incentives. These customers tolerate risks of recovered product use and are frequent buyers of RSC-enabled services. Products well suited for RSC-operations are designed for multiple use-cycles, easy inspection and recoverability. They are based on stable and slowly developing technology platforms, made of modules and standard components, and are reliable in every use cycle. A well suited distributor network is homogenous and the individual distributors (including retailers) in the network have good reputations, a detailed knowledge of the manufacturer's installed base locations, and value RSC-enabled services.

Suggestions for future research

Table 3 and 4 show that three of the 15 RSC-functions have received 76% of academic attention. The study therefore suggests future research into the remaining 12 functions. Specific research questions concern the benefits, costs and risks of operating the 12 functions. Are these functions worth the effort and under which circumstances? How does product design impact profitability? How do customers within these functions differ from the firm's primary market customers? Does addressing these new customer segments (recyclers, the firm's supplier network, and independent recovery firms) add complexity to the firm's sales and logistics operations? How does the firm best organize sales and delivery to new markets? Does the firm risk enabling a new set of competitors or passing knowledge to third parties?

The 56 contingency factors show that recovering and reselling end-products to the firm's primary market relates heavily to primary market structure, customer behavior, and product design. However, the relationship between the RSC and the profit-contribution of other business functions is under-researched. For example, the purchasing function contributes to the firm's bottom line by lowering prices (e.g. by contract bundling and good personal relationships with suppliers). Reusing recovered components may decrease the purchasing function's efforts. Another example is the profit-contribution of the firm's service function. Profits from servicing the firm's installed base may increase because sales of recovered products at lower prices to customers that are unaddressable with the firm's virgin products increases the firm's installed base.

In addition to the relationship between the RSC and other business functions, the relationship between the RSC and the firm *at large* is under-researched as well. The study therefore suggests future research into the mechanisms that connect the RSC to the competitiveness of the overall firm. Specific research questions include whether, how, and why the firm's ability to compete increases or decreases with RSC-function deployment.

Conclusions and contributions

The paper has identified 15 functions for how the RSC can contribute directly to the firm's financial performance by either increasing revenue or reducing costs. Examples include recovery and resale of end-products, recovery and reuse of components in the firm's service operations, and resale of core materials upstream to the materials original supplier. The review has identified 56 exogenous contingency factors that influence the size of the RSC's financial contribution. These factors concern market structure, customer behavior, and product design.

Contribution to theory

While literature contains several reviews about managerial policies related to the RSC, this paper constitutes the very first review of RSC-contribution opportunities available to manufacturers as well

as the first review of exogenous contingency factors. The study contributes to the literature stream that view the RSC with a business perspective (Guide and Van Wassenhove, 2006) by synthesizing the RSC's value delivery mechanisms and the contingency factors that explain why firms in some contexts can operate profitable RSC, while firms in other contexts cannot.

Contribution to practice

For managers considering RSC-implementation, the question is which RSC-functions will deliver the maximum financial contribution. The study provides managers with an elaborate list of 15 RSC-functions. Furthermore, the study aids implementation decisions by providing the set of factors that influence costs and benefits. The study's results can be applied directly in decisions about implementing recovery and resale of end-products. The study suggests the following decision-making process:

1. Assess the fraction of green, functionality-oriented customers
2. Determine this market segment willingness to return core products and purchase recovered products
3. Assess the virgin product cannibalization degree within this and other market segments
4. Determine product recoverability and number of use cycles
5. Assess recovered product prices; the acquisition, reverse logistics and recovery costs; and other financial effects (deterrence of competitor entrance, reduced scrapping costs, etc.)

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